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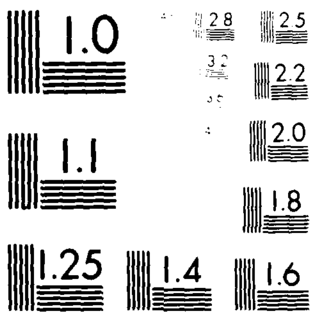

MICROCOPY RESOLUTION TEST CHART

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MATERIALS NOTE 130

AN ASSESSMENT OF THE CORROSIVE POTENTIAL OF THE CHEMICALS USED IN PENETRANT TESTING TOWARDS AIRCRAFT STRUCTURAL MATERIALS

by

R. S. G. DEVEREUX and L. WILSON

Approved for Public Release.

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SUMMARY

Various chemicals are used in non-destructive penetrant testing for cracks in aircraft structural materials. Tests have been carried out to assess the corrosive effect of these chemicals on aircraft aluminium alloys. These tests showed that the chemicals themselves are unlikely to have any deleterious effects. However, water used in removing the chemicals from the test area could cause surface corrosion and increase the rate of stress corrosion crack propagation if it is not removed at the conclusion of testing.

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16. *ABSTRACT*

Various chemicals are used in non-destructive penetrant testing for cracks in aircraft structural materials. Tests have been carried out to assess the corrosive effect of these chemicals on aircraft aluminium alloys. These tests showed that the chemicals themselves are unlikely to have any deleterious effects. However, water used in removing the chemicals from the test area could cause surface corrosion and increase the rate of stress corrosion crack propagation if it is not removed at the conclusion of testing.

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1. INTRODUCTION

Penetrant testing is one of the non-destructive inspection techniques used by the Royal Australian Air Force (RAAF) to detect cracks in aircraft structures. The procedure most commonly employed consists of the following steps:

(i) the surface to be inspected is cleaned with a solvent;

(ii) a fluorescent penetrating liquid is applied to the surface;

(iii) excess penetrant, treated with an emulsifier, is washed off the surface with tap water;

(iv) the surface is dried;

(v) an absorbent developing powder is applied which attracts the fluorescent liquid from the interfaces of any cracks;

(vi) the surface is examined under ultra-violet radiation for indication of the presence of cracks; and finally

(vii) the developer is removed from the surface by washing with tap water or by compressed air.

Recently, the RAAF expressed concern at the likelihood of chemical residues from the various steps in the penetrant-testing procedure causing corrosion of the structures being examined and requested that this matter be investigated. This report describes tests carried out to assess the effect of the various chemicals used in the penetrant test procedure on the corrosion and stress-corrosion of aluminium alloys used in aircraft structures.

2. CORROSION TESTS

2.1 Visual and Weight-loss Corrosion Tests

Aluminium alloy 2024-T3 was chosen for these tests because it was considered to be one of the more corrosion-prone aluminium alloys commonly used in aircraft structures. Test specimens (50 mm long by 25 mm wide by 12 mm thick) were polished to a 600 grit finish, degreased, and weighed. The test solutions were:

(i) Zyglo Cleaner ZC7;

(ii) Zyglo Penetrant ZL22;

(iii) Zyglo Emulsifier ZE3;

(iv) Zyglo Emulsifier ZE3 (20%) and tap water (80%);

(v) a 50/50 slurry of Zyglo developer powder ZP4A and tap water—this was used as the powder developer is sometimes removed by washing off with water; and

(vi) tap water.

Each test consisted of suspending each test specimen in a glass bottle, covering it with 100 ml of one of the test solutions (above) and sealing with a plastic lid. Each specimen was inspected regularly *in situ*; the observations made are recorded in Table 1. All tests were carried out in duplicate.

TABLE 1

Corrosion Test Observations

Test solution	Observations made after			
	One day	One week	One month	Two months
Cleaner	No change	No change	No change	Slight pitting of both specimens
Penetrant	No change	No change	No change	No change
Emulsifier	No change	No change	No change	No change
Emulsifier plus water	No change	Specks of white precipitate had formed on the specimens	The amount of white precipitate had increased	The surface of both specimens had darkened and the amount of white precipitate had increased
Developer plus water	No change	Specks of white precipitate had formed on the specimens	The amount of white precipitate had increased	The surface of both specimens had darkened and the amount of white precipitate had increased
Tap water	Light staining of both specimens had occurerd	A white precipitate had formed on both specimens	A white precipitate covered each specimen and was dispersed throughout the solution	The amount of white precipitate had increased considerably

After 70 days, the specimens were taken from their solutions, corrosion products removed by scrubbing with a soft bristle brush, washed with alcohol, dried, and weighed. Calculated corrosion rates, based on weight losses are shown in Table 2.

TABLE 2

Corrosion Rate Results

(based on weight loss)

Test solution	Average corrosion rate (mg/cm^2/70 days)	Average corrosion rate (mm penetration/year)
Cleaner	Nil	Nil
Penetrant	Nil	Nil
Emulsifier	Nil	Nil
Emulsifier plus water	1·68	0·032
Developer plus water	1·66	0·031
Tap water	1·73	0·033

Tables 1 and 2 show that the chemicals used in the penetrant test method do not themselves cause severe corrosion of aluminium alloy 2024-T3. However, when water is mixed with the chemicals, significant corrosion does occur.

2.2 Stress Corrosion Tests

Aluminium alloy 7075-T651 was chosen for these tests because of its known susceptibility to stress-corrosion cracking. Seven Double Cantilever Beam (DCB) specimens[1] manufactured from 76 mm plate, containing "pop-in" pre-cracks were bolt-loaded in the short transverse direction. The lengths and opening displacements of the cracks introduced into the specimens were measured and the specimens treated as follows:

Specimen 1—Cleaned using Zyglo Cleaner ZL7.

Specimen 2—Coated with Zyglo Penetrant ZL22.

Specimen 3—Cleaned and coated with penetrant.

Specimen 4—Treated with Zyglo Emulsifier ZE3.

Specimen 5—Cleaned, coated with penetrant, excess penetrant treated with emulsifier and the emulsion removed by washing with tap water.

Specimen 6—Treated with Zyglo Developer ZP4A.

Specimen 7—Cleaned, coated with penetrant, excess penetrant treated with emulsifier, emulsion removed with tap water, dried in air, and developer added.

The length of crack in each specimen was measured every 24 hours for 46 days. Figure 1 shows the plots of increase in crack length versus time for each of the specimens. The only specimens with significant increases in crack length were numbers 5 and 7; both of these were washed in tap water at some stage of their preparation.

3. CONCLUSIONS

Visual and weight-loss corrosion tests and stress-corrosion tests indicate that the chemicals used in penetrant-testing are unlikely to cause corrosion problems in aircraft structures. However, any water left behind or trapped in cracks would be deleterious. Care should therefore be taken to dry aircraft structures thoroughly after the removal of the emulsifier and at the conclusion of penetrant-testing.

REFERENCE

1. Hyatt, M. V.—Use of precracked specimens in stress corrosion testing of high stiength aluminium alloys. *Corrosion*, Vol. **26**, 487 (November 1970).

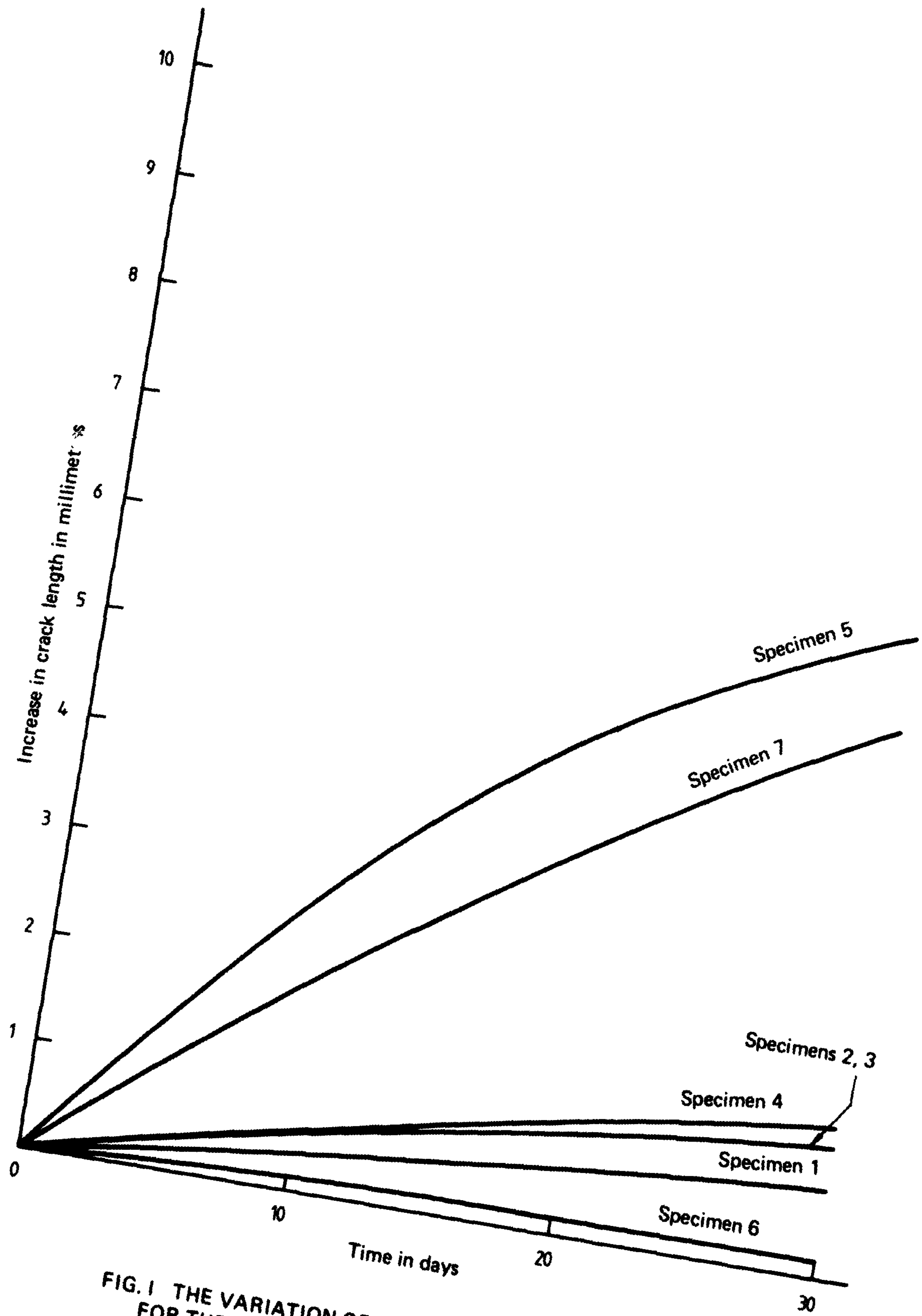

FIG. I THE VARIATION OF CRACK LENGTH WITH TIME FOR THE STRESS CORROSION TEST SPECIMENS

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